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Agronomic management of Indian mustard [*Brassica juncea* (L.) Czern & Cosson]

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Introduction

Indian mustard (*Brassica juncea* L.), a member of the Cruciferae family, also known as Indian mustard, brown mustard, Chinese mustard, and oriental mustard, is one of the major *Rabi* season oilseed crops in the world. India ranks third among the major rapeseed mustard growing countries of the world with 9.98% of the world's area under Rapeseed mustard cultivation. Domestic production of edible oil meets only 50% of the total requirement, while most of the requirement is met by importing from other countries. Despite leading producer of vegetable oil in the world, India is the largest importer of edible oil in the world. The attainment of self-sufficiency in edible oil is possible if the production potential of annual edible oilseed crops is harnessed through improved technologies for managing nutrients and weeds. Nepal, Russia, and Canada are currently the largest producers of mustard, globally. However, it is also cultivated in India, China, Pakistan, Poland, Bangladesh, Sweden and France. In India, mustard is predominantly cultivated in the states of Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Gujarat. It is also cultivated in the plains of some northeastern states, which comprise Bihar, Chhattisgarh, Jharkhand, Orissa, Eastern Uttar Pradesh, Sikkim, and West Bengal. In Haryana, the major mustard-growing districts are Hisar, Bhiwani, Rewari, Mahendragarh and Rohtak. In the world, the total area, production, and productivity of rapeseed mustard were 19.8 million hectares, 61.64 million tonnes, and 1980 kg ha^{-1} during 2020-21, while the area, production, and productivity of rapeseed mustard in India and Haryana were 10.74million hectares, 13.54million tonnes, 1261 kg ha^{-1} and 38000 million hectares, 45370 million tonnes, 1194 kg ha^{-1} (Indiastat, 2023). Among the oilseed crops grown in the country, it occupies about 24.70 percent of the total area with 48.28 percent of the total oilseed production in India.

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Importance of rapeseed-mustard:

Mustard seeds contain high levels of copper, calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, manganese, and selenium. Mustard seeds are also a great source of several B vitamins like thiamin, riboflavin, and vitamin B_6. Mustard oil has about 60% monounsaturated fatty acids (42% erucic acid and 12% oleic acid), 21% polyunsaturated fats (6% omega-3 alpha-linolenic acid and 15% omega-6 linoleic acid), and about 12% saturated fats. Mustard seeds offer a wide range of health benefits. Incorporating these flavourful seeds in a diet can reduce headaches, improve digestion, support heart health, strengthen bones and teeth, benefit the skin and hair, delay aging, provide antioxidant protection, control blood sugar, *etc*. Including mustard greens in the diet can boost the immune system, improve digestion, enhance skin health, maintain eyesight, promote bone density, improve heart health, and prevent cancer potentially. Moreover, mustard greens are known to be packed with antioxidants which may help in the management of diabetes and obesity.

Seedbed preparation:

To achieve optimal growth and yield for mustard plants, it's crucial to maintain a firm, moist, and uniform seedbed. This ensures proper seed-to-soil contact, even planting depth, and efficient moisture absorption, leading to uniform germination. Tillage plays a significant role in both crop growth and grain yield. There are different types of tillage systems, such as:

- **Conventional Tillage:** This method involves the use of a moldboard plow followed by disc harrowing. It is an extensive form of soil disturbance, which can lead to better soil aeration and improved drainage. However, it may also result in higher fuel consumption and soil erosion.
- **Reduced Tillage:** In this approach, disc plowing is followed by disc harrowing. It is a more moderate form of soil disturbance, which helps in maintaining soil moisture and reducing soil erosion. This method also helps in conserving energy, as it requires less fuel consumption compared to conventional tillage.
- **Zero Tillage:** This method involves sowing crops directly under uncultivated soil. It is the least invasive form of tillage and helps in maintaining soil structure, improving water retention, and reducing soil erosion. Moreover, zero tillage can lead to higher organic matter content in the soil, which can contribute to better crop growth and yield.

When choosing a tillage system for mustard cultivation, it is essential to consider

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factors such as soil type, climate, and the specific requirements of the mustard variety being grown. The right tillage method can significantly impact the overall success of the crop, leading to higher yields and better-quality produce.

Sowing:

Seed and sowing play a crucial role in the successful cultivation of mustard, as they influence various factors such as growth, yield, and resistance to pests and diseases. This section provides an overview of some key aspects related to seed priming, sowing time, and planting techniques in mustard cultivation.

- **Seed priming** is a technique that enhances early germination and growth of mustard seeds, even in unfavorable conditions. Soaking seeds in specific solutions can improve germination rates and overall crop performance. The rate of imbibition varies among different mustard varieties, which can be useful for identifying suitable options for abiotic stress conditions.
- **Sowing time** is another critical factor that affects mustard production. Optimal sowing dates allow for suitable environmental conditions throughout the growth stages, leading to higher yields. Different varieties respond differently to planting dates, so it's essential to consider this when planning sowing schedules. Delayed sowing can result in poor growth, low yield, and reduced oil content.

Sowing techniques, such as broadcast, line sowing, ridge and furrow, and broad bed and furrow methods, can also impact mustard cultivation. The choice of technique depends on factors like land resources, soil conditions, and management practices. Broadcasting is often successful in higher soil moisture regimes, while line sowing is beneficial under normal and conserved moisture conditions. Paira or utera sowing, where the next crop is sown in the standing previous crop without tillage, has shown promising results in eastern India. Ridge and furrow sowing has also demonstrated improved growth parameters and yield in *Brassica juncea*.

In summary, understanding and optimizing seed priming, sowing time, and planting techniques can significantly contribute to mustard crop success under low temperature and radiation regimes. These factors should be carefully considered and tailored to specific local conditions and varieties to achieve maximum yield and quality.

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Crop Geometry:

In rapeseed-mustard plants, the competitive ability and yield are influenced by factors such as plant density, row spacing, soil fertility, and environmental conditions. The optimal plant population density and row spacing can vary depending on these factors. A uniform distribution of plants allows for efficient use of resources and suppresses weed growth, leading to higher yields. Narrower row spacing generally promotes vegetative growth, but wider row spacing can result in taller plants with increased seed yield. As row spacing increases, crop maturity days may also increase, and plants may grow taller with more branches, pods, and seeds per plant. However, wider rows can lead to some lower leaves receiving less light, which may negatively impact yield. The recommended spacing for mustard is 30 × 10 cm, while for hybrids, it is 45 × 10 cm. In specific locations, such as Kumher and Pantnagar, different plant spacings may result in higher seed yields, but overall, the 45 × 10 cm and 30 × 15 cm spacings have shown promising results. To achieve the best yield for rapeseed-mustard plants, it is essential to consider the specific environmental conditions, genotype, and other factors when determining the optimal plant population density and row spacing.

Plant population and shading effect:

In summary, the study on *Brassica juncea* (Var. laxmi) found that dense plant populations can reduce yield due to mutual shading, impacting the photosynthetically active leaf area. This effect was more pronounced at the 91-110 DAS stage compared to the 71-90 DAS stage. Specific leaf weight, crop growth rate, and net assimilation rate were negatively influenced by 50% shading at the 71-90 DAS stage, while net assimilation ratio remained unaffected by 25% shading. However, a 50% shading at the 91-110 DAS stage had a more significant impact on these factors, indicating that higher shading levels can be more detrimental to plant growth and yield at later development stages.

Cropping system:

Physiography, soils, geological formations, climate, cropping patterns, and the development of irrigation and mineral resources play a significant role in determining the choice of crop varieties and cropping systems. In major mustard-growing areas, fallow mustard is a popular sequence. However, recent studies have revealed that certain crops can lead to better resource utilization and higher returns when incorporated into mustard-based cropping

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systems. By exploring and adopting these alternative crops, farmers can improve their yields and overall profitability.

Fertilizer management:

In summary, adequate nutrient supply, particularly nitrogen and phosphorus, plays a crucial role in increasing seed and oil yields in mustard crops. The recommended dose of fertilizers varies depending on factors such as climate, soil type, time, and cropping system. Nitrogen application efficiency is influenced by the rate, source, and method of fertilizer application. Optimal nitrogen levels (60-90 kg/ha) have been found to improve yield attributes and seed yield, while phosphorus levels (up to 80 kg/ha) enhance seed yield due to increased secondary branches and siliquae per plant. Split application of nitrogen in three equal doses has shown better results compared to two split doses. It is essential to apply nitrogen with pre-sowing irrigation and adjust the application method according to local conditions and practices.

Rapeseed-mustard, as an oilseed crop, has a high requirement for sulfur, which plays a crucial role in promoting oil synthesis, seed protein, amino acids, enzymes, glucosinolate formation, and chlorophyll production. This essential nutrient significantly contributes to mustard yield, with studies showing increases of 12 to 48% under irrigation and 17 to 124% under rainfed conditions. In terms of agronomic efficiency, each kilogram of sulfur applied can increase mustard yield by 7.7 kilograms. The oil content in Canola-4 and Hyola-401 is 3% higher than the hybrid "PGSH-51" due to the combined effect of varying nitrogen and sulfur doses. Additionally, the oleic acid content in these hybrids is double that of "PGSH-51." In "PGSH-51," erucic acid levels ranged from 23.2% to 29.4%. Higher sulfur levels led to a 2-3% reduction in erucic acid content, while lower nitrogen levels resulted in a 3% decrease in erucic acid with a corresponding increase in oleic acid. This suggests that higher doses of sulfur combined with low doses of nitrogen can affect the chain elongation enzyme system, leading to reduced erucic acid synthesis.

Mustard, being a sensitive crop, is highly susceptible to micronutrient deficiencies, particularly zinc and boron. These deficiencies can significantly impact its growth and productivity. In a study, it was observed that by applying 12.5 kg of ZnSO4 per hectare, the seed yield increased by 8.5%. This demonstrates the importance of adequate zinc supply for mustard cultivation. However, it is also noteworthy that the seed yield showed diminishing returns with an increase in the ZnSO4 dose. This indicates that there might be an optimal level

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of zinc application for mustard plants, beyond which the additional zinc may not contribute significantly to the seed yield. Moreover, the harvest index (HI), which is the ratio of grain yield to the total biomass, was also significantly affected by the zinc application. This suggests that zinc plays a crucial role in the partitioning of assimilates towards the seeds, leading to higher yields.

In conclusion, ensuring proper zinc and boron nutrition for mustard plants is essential for optimizing their growth and productivity. However, it is also crucial to maintain an optimal balance of these micronutrients to avoid wastage and environmental concerns.

Water management:

In summary, rapeseed-mustard crops are sensitive to water scarcity, and regions like Rajasthan, Gujarat, Haryana, and Punjab have implemented irrigation systems to support their growth. Irrigation at critical stages positively impacts the crop's water use efficiency and yield. Two irrigations, one at the flowering stage and another at the siliqua formation stage, have been observed to increase seed yield by 28% compared to rainfed plots. Increased water supply enhances various factors like leaf water potential, stomatal conductance, light absorption, leaf area index, seed yield, and evapotranspiration while reducing canopy temperature. Studies have shown that the water use efficiency is highest with one irrigation at 45 days after sowing (DAS) and that crops receiving two irrigations at pre-flowering and pod-filling stages produce about 33% more seeds than unirrigated crops. Single irrigation at the vegetative stage and two irrigations at the vegetative and pod formation stages are most beneficial for yield. Overall, proper irrigation management significantly affects rapeseed-mustard crop yield and water use efficiency. This practice can help maintain the optimal nutrient supply to the mustard crop while minimizing the negative impacts of saline water. Additionally, proper drainage systems should be in place to manage excess salts and prevent their accumulation in the root zone. It is essential to monitor the soil's electrical conductivity (EC) and adjust the irrigation water's EC accordingly. The ideal EC for mustard cultivation is typically between 2 and 4 dS/m. If the irrigation water's EC is higher than this range, it may be necessary to dilute it with freshwater or use other water management techniques like partial root zone drying or deficit irrigation. Furthermore, the use of saline-tolerant mustard varieties can help mitigate the effects of poor irrigation water quality. Breeding programs and selection of genotypes with higher salt tolerance can contribute to improving the overall productivity of mustard crops under such conditions.

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In conclusion, ensuring the quality of irrigation water is crucial for optimal mustard production. Proper management, treatment, and selection of suitable water sources, along with appropriate agricultural practices, can help minimize the negative impacts of poor irrigation water quality on mustard crops. This will ultimately contribute to increased crop yields and better agricultural sustainability.

Weed management:

Weeds significantly impact crop production in various ways, such as competing for resources like water, light, space, and nutrients. This competition can lead to a decline in crop yield, ranging from 15-30% to total failure in some cases. To address this issue, farmers have adopted various methods for weed control, with herbicides being a popular choice due to their efficiency, increased profit, and reduced labor requirements. Some effective weed control methods for mustard include hand weeding, fluchloralin pre-plant incorporation, wooden hand ploughing, polythene mulch, and a combination of these techniques. These methods help maintain a weed-free environment, which results in higher seed yields. Broomrape (Orobanche) is a major parasitic weed that causes significant damage to mustard crops, reducing both yield and quality. To combat this issue, farmers can consider using preceding crops that help reduce Orobanche infestation in mustard, such as cowpea, black gram, moth bean, sunn hemp, cluster bean, and sesame. Additionally, cultural practices like mulching and hoeing can be beneficial in controlling weeds and improving mustard yield.

In conclusion, managing weeds is crucial for maintaining high crop yields and overall productivity in mustard farming. Employing effective weed control methods, such as herbicides, hand weeding, mulching, and hoeing, can significantly improve mustard yield and ensure better nutrient use efficiency.

Conclusion:

To summarize, the growth in oilseed production, particularly mustard, can be enhanced through various strategies. Firstly, exploiting genetic resources and employing breeding and biotechnological techniques can help break yield barriers. Secondly, focusing on horizontal growth in rapeseed-mustard production areas with lower yields than the national average can contribute to overall growth. Developing production technologies for different agroecological cropping systems and utilizing unutilized farm situations can also help expand mustard cultivation. Adopting such cropping systems could potentially bring an additional 1 million hectares under cultivation. Improving existing practices like proper land preparation, timely sowing, and using better quality seeds can significantly impact productivity. Implementing site-specific nutrient management and adopting an integrated approach to plant-water, nutrient, and pest management are crucial for achieving higher yield targets. Lastly, extending rapeseed-mustard cultivation to new areas under different cropping systems will play a vital role in increasing and stabilizing productivity to reach the target of 24 million tonnes of oilseed production by 2020.